

RESOLVED IMAGERY AS A TOOL FOR SPACE SCIENCE AND EXPLORATION. J.A. Christian¹, J. McMahon², D.N. DellaGiustina³, C.M. Ernst⁴, R.P. Russell⁵, D.R. Golish³, J.S. McCabe⁶, J. Keller², D.S. Lauretta³, P. Gay⁷, P. Schoch¹; ¹Rensselaer Polytechnic Institute, ²University of Colorado at Boulder, ³The University of Arizona, ⁴Johns Hopkins University Applied Physics Laboratory, ⁵The University of Texas at Austin, ⁶NASA Johnson Space Center, ⁷Planetary Science Institute (email for J.A. Christian: chrisj9@rpi.edu).

Introduction: Of all the instruments commonly flown on exploration spacecraft, few are as flexible as the camera in the breadth of science problems they address. Even fewer instruments are so frequently called upon to simultaneously support scientific analysis, mission-critical navigation, and day-to-day operations. Thus, the authors find the study of space imagery to be a naturally interdisciplinary endeavor where the pursuit of science and exploration are intertwined.

Resolved imagery provides a gateway for the deeper understanding and safer exploration of airless bodies such as the Moon, Phobos & Deimos, and near Earth asteroids (NEAs). We believe there are four synergistic areas (or “Themes” in Fig. 1) whose simultaneous and coordinated advance could lead to a revolution in how we operate current and future exploration spacecraft.

Central to our philosophy is tighter integration between the science and engineering communities. The diversity of ways imagery can be used has led to a fragmentation in communities who could all benefit from a more coordinated approach. Disparate and incompatible imaging pipelines amongst planetary scientists and engineers represent a significant risk to future missions relying on imagery for science, navigation, and teleoperation. This lack of coordination also wastes resources as common problems are solved multiple times.

Theme 1: Images reveal a body’s shape, structure, and dynamics: Determination of a body’s shape or terrain is one of the most useful science data products

that may be derived from resolved imagery of space objects. The shape provides insight into important surface attributes—such as impact crater morphology or the regolith’s physical properties—and is inextricably linked to the body’s internal structure and dynamics.

Theme 2: Images facilitate spatially-resolved photometric modeling: The photometric response of a surface provides an indirect measure of the composition and structure of that surface. As a result, photometric modeling has been applied to every explored body in the Solar System—and improvements in this field have potential for far-reaching impact.

Theme 3: Images enable optical navigation (OPNAV): OPNAV is the practice of using images to estimate the relative position and attitude between the spacecraft and an observed celestial body. Variants of this technique have been a key capability for every crewed lunar system (e.g., Apollo, Orion) and every contemporary mission to a small body (e.g., NEAR, OSIRIS-REx).

Theme 4: Image-based tools improve teleoperator performance and cognition: Images are the window through which a teleoperator views a robotic spacecraft’s environment. As a consequence of our drive towards autonomy, the operator necessarily sees fewer images—and hence produces a degraded mental map. This degraded map negatively affects the operator’s ability to quickly make correct decisions, making the detailed study of teleoperator cognition essential.

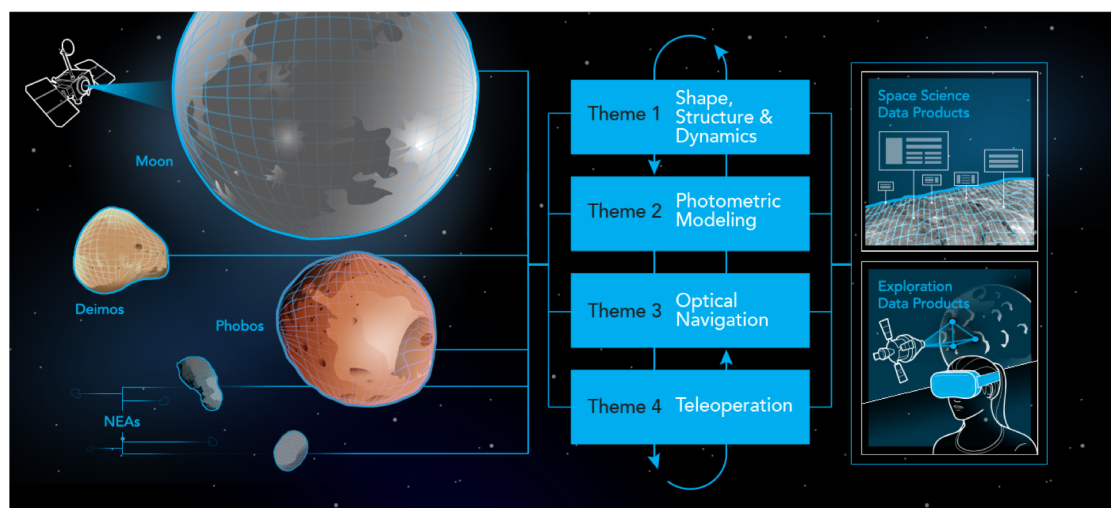


Figure 1. Resolved imagery enhances our ability to produce valuable science and exploration data products.